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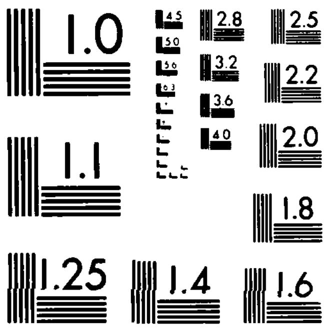

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An analysis of aerobic capacity in a large United States population

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This study presents a description of aerobic capacity in a large U.S. population comprised of 1,514 males and 375 females. Such influencing factors as age, training state, occupation and body composition were evaluated. The population consisted of new recruits entering the U.S. Army from civilian life as well as soldiers in a variety of assignments and physical training programs. Age ranged from 17 through 55. Aerobic capacity was determined as maximal oxygen uptake measured directly by the Douglas bag technique during a standard discontinuous treadmill running procedure with the exception of one older aged

group. New male and female recruits, representing a young civilian population, entered the service with VO_2max of 51 and 37 $ml.kgBW^{-1}$, respectively, and thereafter increased 5-10% during initial basic training. The difference between genders, 30% on an absolute basis, was 14% when expressed as a function of lean body mass. Aerobic capacity was less after occupational training and continued to decrease with age at an average yearly rate of 10% or 0.5 $ml.kgBW^{-1}.min^{-1}$. Aerobic capacity varied with intensity of the occupational physical demand except in groups with significant physical training programs. The first large U.S. population study of aerobic capacity, using a direct treadmill procedure, demonstrates levels consistent with any previously reported population.

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ABSTRACT

This study presents a description of aerobic capacity in a large U.S. population comprised of 1,514 males and 375 females. Such influencing factors as age, training state, occupation and body composition were evaluated. The population consisted of new recruits entering the U. S. Army from civilian life as well as soldiers in a variety of assignments and physical training programs. Age ranged from 17 through 55. Aerobic capacity was determined as maximal oxygen uptake measured directly by the Douglas bag technique during a standard discontinuous treadmill running procedure with the exception of one older aged group. New male and female recruits, representing a young civilian population, entered the service with $\dot{V}O_2$max of 51 and 37 $ml \cdot kgBW^{-1} \cdot min^{-1}$, respectively, and thereafter increased 5-10% during initial basic training. The difference between genders, 30% on an absolute basis, was 14% when expressed as a function of lean body mass. Aerobic capacity was less after occupational training and continued to decrease with age at an average yearly rate of 10% or 0.5 $ml \cdot kgBW^{-1} \cdot min^{-1}$. Aerobic capacity varied with intensity of the occupational physical demand except in groups with significant physical training programs. This first large U.S. population study of aerobic capacity, using a direct treadmill procedure, demonstrates levels consistent with any previously reported population.

Key Words: Maximal O_2 Uptake, Aerobic Capacity, Aging, Gender Differences, Physical Training, Treadmill Testing.

In 1966 Shephard (36) compiled the world's available literature on population samples of aerobic capacity as assessed by maximal oxygen uptake ($\dot{V}O_2$max). Acknowledging the difficulty in interpreting and comparing individual studies when using different methodologies and small sample sizes, he concluded that there was a striking difference between Scandinavian values and those from the remainder of Europe and North America. As evidence he cited reports of the $\dot{V}O_2$max of 63.7 $ml \cdot kgBW^{-1} \cdot min^{-1}$ for Swedish soldiers (21) and 36.5 $ml \cdot kgBW^{-1} \cdot min^{-1}$ for US servicemen (4). Subsequently in 1974, Bailey, et al (3) reported a comprehensive survey of aerobic capacity in the Canadian civilian population which again indicated North American values below Scandinavian levels. These comparisons included the use of correction factors to adjust for differences in methodology, such as between cycle ergometer and treadmill and between direct and predictive techniques (37).

Comprehensive descriptions of aerobic capacity in United States populations are remarkably lacking. Many studies have reported aerobic fitness values of small specific groups, for example, athletes (12,33), laborers (23), students (19,26) and adolescents (20,30) with a mixture of measuring techniques. The Army presents a suitable population for such an assessment of aerobic fitness in young to middle age adults because of its broad representation of the national population as well as its accessibility. Individuals enlisting in the U.S. military service represent as heterogenous population as may practically be found since they come from most segments of American society. It is therefore surprising that so few studies have been made of this group with direct measures of $\dot{V}O_2$max. Balke and Ware (4) reported values on nearly 500 Air Force personnel using a run test to predict $\dot{V}O_2$max while Cooper and Zechner (6) estimated aerobic capacity on 9500 Air

Force personnel with a twelve minute run for distance test. Froelicher, et al (14) evaluated 710 aircrewmen by direct measurement and more recently we (31) reported on values of directly measured $\dot{V}O_2max$ before and after Army basic training.

This report presents data of directly measured $\dot{V}O_2max$ on a total of 1,889 subjects, 1,514 male and 375 female activity duty personnel from a variety of units and assignments throughout the U.S. Army. Of these, 422 were new recruits coming from civilian life prior to the commencement of their training and therefore are representative of the young United States population. The remainder of the sample permits an analysis of the influence of such factors as gender, age, training status, occupation and body composition in a large, diversified population. All individuals were measured for $\dot{V}O_2max$ by uphill treadmill running by the same investigators and the same technique with only one minor exception described later.

Subjects

All subjects were active duty soldiers between the ages of 17 and 55 years. Their medical records were reviewed and, in most cases, a physical examination was administered prior to participation. Those free of significant disease or debilitating orthopedic injuries were utilized for the studies.

Informed voluntary consent was obtained in all cases. The rate of volunteerism within the populations identified and accepted for testing averaged 94%. There was no evidence that the results were skewed due to the process of volunteerism. Refusal to volunteer for the studies appeared to be unrelated to perceived level of physical fitness.

Eight separate groups were studied in this cross-sectional assessment in order to provide data on a number of factors on aerobic fitness. These groups are summarized in Table 1. The new recruit groups (Group I and II) consisted of personnel randomly selected from all individuals who reported for basic training at a U.S. Army training center during a one month period (approximately 1200 males and 600 females). The sample consisted of individuals from primarily the eastern half of the United States. It is believed that the random selection cut across such variables as race, ethnicity, intelligence, athletic experience, habitual activity and nutritional status.

Group III and IV consisted of individuals similarly selected at the same training center at the end of their seven weeks of basic initial entry training (commonly referred to as "boot camp"). Group V consisted of male soldiers who had just completed an additional four to eight weeks of advanced occupational training prior to being assigned to their first organizational unit. Individuals in this group were randomly selected from rosters of their newly assigned units.

Group VI consisted of male personnel from a large number and wide variety of assignments and organizational units within the continental United States. These personnel were also randomly selected from unit rosters. This group represented a wide range of ages, occupations and physical training programs (from none to extensive).

Group VII consisted of male personnel who had been assigned for 5-6 months to a combat infantry division stationed overseas. This particular unit, at the time of these measurements, participated in a running program where all personnel ran five days per week for a total of 16-18 miles per

week at a 7.5 to 9 minute per mile pace. Thus, this group represented a comparatively homogeneously trained sample as compared to Group VI which represented a wide range of training intensities.

Group VIII was added to this study to provide an older age range of 40 to 55 years. It consisted of both officers and non-commissioned officers from two Army posts.

Methods

On the day of testing, body weight and height were measured in gym shorts. Percent body fat was estimated from four skinfolds with a Harpenden caliper and derived with the age and gender corrected equations of Durnin and Womersley (13). Two of the authors, who matched their technique, performed all the skinfold measurements.

Aerobic capacity was determined by the direct measurement of $\dot{V}O_2max$ using the discontinuous running treadmill protocol described by Taylor et al (38) as modified by Mitchell, et al (27) and illustrated in Figure 1.

Male subjects first performed a preliminary warm-up run at 6 mph (160.9 m/min) for 6 minutes. This was followed by 3 or 4 subsequent runs of 4 or 3 minutes duration each at either 6 or 7 mph at increasing grades of 2.5% increments until a leveling off of $\dot{V}O_2$ had been achieved, i.e., an increase of less than 0.15 $\ell \cdot min^{-1}$ per 2.5% grade increment. A 5-10 minute rest period intervened between each run. Expired gas was collected through a mouthpiece attached to either a triple-J or Koegel-Y valve into Douglas bags during the final minute of each run. An aliquot of the expired gas was analyzed for gas fractions with either a Beckman E-2 or Applied Electrochemistry S3-A oxygen analyzer and a Beckman LB-2 carbon dioxide

analyzer. Gas volumes were determined with a Collins chain-compensated 120 liter Tissot spirometer. Heart rate was recorded electrocardiographically during the final minutes of each run. Females followed the same protocol except that they began at 5 mph (134 m/min) during the warm-up run followed by speeds of 5 or 6 mph during the incremental loading.

An exception to the above $\dot{V}O_2$max procedure took place in the 40-55 year age subjects (Group VIII). In order to obtain quality multi-lead electrocardiographic tracings in this group, a continuous incremental walking procedure was employed using a fixed speed of 3.3 mph (90 m/min) while raising the grade 5 percent very 3 minutes (41). The test proceeded to maximal performance ability rather than $\dot{V}O_2$ plateau. Thus, in this group the reported $\dot{V}O_2$ value is more properly referred to as $\dot{V}O_2$peak rather than $\dot{V}O_2$max even though there was evidence of plateauing in many subjects. Unpublished data from our laboratory indicate that the walking protocol results in a $\dot{V}O_2$peak value 2 $ml.kgBW^{-1}\cdot min^{-1}$ on the average below the running $\dot{V}O_2$max value.

Group VI and VII data were assessed to determine the effects of occupation on aerobic capacity. Occupations were recorded and divided into three groups according to the rated severity of aerobic demand according to a procedure previously described from our laboratory (40). The most demanding tasks for each occupation were assigned a caloric expenditure rate and this was used for assignment of the occupation to one of three groups: low, less than 7.5; medium, 7.5 - 11.25; and high, greater than 11.25 kilocalories per minute for the most demanding tasks performed on a routine basis within the occupation.

Results

The data (mean ± SD, and ranges) for each group are summarized in Tables 2 through 5. Table 2 presents values for 210 male and 212 female new recruits who had just entered the service from civilian life and thus represent a young United States population. Maximal heart rate was the only variable which did not differ significantly between genders. On an absolute basis, $\dot{V}O_2$max of the females was 61% of the males. When expressed relative to body weight and lean body mass, females were 73% and 86% of the male values, respectively. A histogram of $\dot{V}O_2$max relative to body weight for both genders is shown in Fig. 2. $\dot{V}O_2$max is distributed normally for both sexes and the extent of overlap is quite small. The range for women is somewhat more narrow than for men.

Table 3 presents data from randomly sampled groups of trainees at the end of their initial seven weeks of basic training. A cross-sectional comparison of these groups with those at the beginning of training (Table 2) indicates that women tend to gain lean body mass without changing their percent of body fat while men lose significant fat with no gain in lean mass. Both men and women showed similar gains in aerobic capacity of about 5 percent.

Table 4 compares data from three groups of soldiers with different physical training programs. Group V were personnel at the completion of occupational training, an additional 4-8 weeks beyond basic initial entry training, for a total training time of 3-4 months. Because occupational training emphasizes job skill development rather than physical development, except for some infantry trades, no further improvement in $\dot{V}O_2$max is evident over the end of basic entry (Group III, Table 3). Group VI, in comparison,

represents a broad range of normal unit assignments within the Army where the emphasis on physical training can vary greatly. While absolute $\dot{V}O_2max$ was not different between Groups V and VI, Group VI had higher body weights and percent body fat which resulted in a significantly smaller relative $\dot{V}O_2max$.

Group VII (Table 4) was composed of a similar age group as VI but represented a single unit which underwent an intensive running program. This was reflected in a higher $\dot{V}O_2max$ both in absolute and relative terms and a lower mean body weight.

Table 5 summarizes data on 503 personnel from the oldest age group studied. The data are separated for officers and non-commissioned officers (NCOs). Officers had more desirable values on the average with a significantly higher aerobic capacity and a tendency toward a lower percent body fat.

Data from Groups VI, VII and VIII were used to depict the decline in aerobic capacity with age (Fig. 3) The decline of 15 $ml \cdot kg\ BW^{-1} . min^{-1}$ over an approximately 30 year span in the relatively untrained Groups VI and VIII represents a 10% or 0.5 $ml \cdot kgBW^{-1} \cdot min^{-1}$ decline in $\dot{V}O_2max$ per year. The well trained Group VII showed only one-half this rate of decline ($p<.01$).

Groups VI and VII were utilized to analyze the effect of the occupational physical intensity (Table 6). A significant effect of occupational activity was demonstrated in whole body $\dot{V}O_2max$ and percent body fat in both groups, regardless of the difference in training intensity consistency represented by the two groups.

Fig. 4 presents a scatter plot comparison of percent body fat with $\dot{V}O_2$ max. The upper panel is data from Group I and the lower panel is from Groups V and VI combined. While the scatter is considerable, definite trends are

evident as represented by correlation coefficients of $-.59$ ($p<.001$) and $-.52$ ($p<.001$) for the two samples. Standard error of estimates were 4.26 and 5.73, respectively. The two regression lines are represented by the equations: $Y=59.603 - .553X$ and $Y=60.635 - .582X$, respectively.

Discussion

This report presents aerobic capacity values on the largest and most diversified sample of the United States population in which measurements have been made by direct determination of maximal oxygen uptake during treadmill exercise. Although the samples are taken exclusively from a military setting, the groups are representative of the diversified racial and occupational makeup of the United States as well as a wide range of physical training involvement. Of particular interest is the new recruit samples which could be thought to be representative of the young eastern United States civilian population. While our samples are not a statistically valid cross-section, the current all-volunteer Army does yield a broad representation of the population across most racial and socioeconomic groups.

The mean values of maximal oxygen uptake reported here do not support earlier inferences (36) that aerobic fitness is inferior in North America compared to northern Europe. Mean values of 51 and 37 $ml \cdot kgBW^{-1} \cdot min^{-1}$ for male and female recruits, respectively, which were 5 to 10 percent higher during further training, are comparable to the highest values reported for general, non-athletic groups. Table 7 compares published reports which have employed direct measures of $\dot{V}O_2$ during treadmill running. The single high value reported by Astrand, et al (2) consisted of physical education students and are not likely to be representative of the general population.

TABLE 4. Effect of training status on maximal O_2 uptake of male soldiers regardless of age

	Completion of Advanced training (Group V)	Stateside Units (Group VI)	Overseas Combat Infantry Division (Group VII)
n	111	199	315
Age, yrs.	20.8 ± 3.4	24.7 ± 5.7	23.5 ± 7.9
Body weight, kg	69.0 ± 9.7*	76.8 ±14.2	73.0 ±10.6
Height, cm	175.8 ± 6.4	176.1 ± 6.9	175.0 ± 6.5
Body fat, % of BW	15.9 ± 4.7*	18.6 ± 6.2	19.5 ± 5.8
$\dot{V}O_2$max, $\ell \cdot min^{-1}$	3.58 ± .45	3.51± .44	3.75± .45*
$\dot{V}O_2$max, $ml.kgBW^{-1}.min^{-1}$	52.3 ±5.0	46.9 ± 7.1*	51.9 ± 6.0

* Mean difference from other groups significant at 5% confidence level.

TABLE 3. Comparison of maximal O_2 uptake in male and female trainees after seven weeks of basic initial entry training. Groups III and IV

	Group III Male	Group IV Female	F/M
n	176	163	-
Body weight, kg*	70.4 ± 8.7	59.9 ± 6.7	.85
Body fat, % of BW*	13.4 ± 4.1	28.0 ± 4.2	-
Lean body mass, kg*	60.6 ± 6.3	43.0 ± 4.2	.71
$\dot{V}O_2$max, $\ell \cdot min^{-1}$*	3.76± 4.3	2.67± 4.2	.71
$\dot{V}O_2$max, ml.kgBW^{-1}.min^{-1}*	53.6 ± 4.4	39.2 ± 3.8	.73
$\dot{V}O_2$max, ml.kgLBM^{-1}.min^{-1}*	62.3 ± 4.3	54.8 ± 5.3	.88

* Mean differences significant at 1% confidence level

TABLE 2: Maximal O_2 uptake, anthropometric and related variables of men and women entering the Army from civilian life, pre-initial entry training, Groups I and II.

Variable	Males (n = 210) Mean ± SD	Males (n = 210) Range	Females (n = 212) Mean ± SD	Females (n = 212) Range	F/M
Age, yrs	19.7 ± 2.2	17 - 25	19.7 ± 1.9	17 - 25	-
Height, cm*	174.7 ± 6.9	153.7-195.1	162.0 ± 6.4	146.7-183.2	-
Body weight, kg*	70.5 ± 10.7	45.8±105.5	58.6 ± 7.0	42.2-77.5	.83
Body fat, % of BW*	15.6 ± 5.6	6.0-32.7	28.4 ± 4.5	12.4-38.8	-
Lean body mass, kg*	59.1 ± 7.0	40.7-80.6	41.8 ± 4.4	32.7-53.1	.71
$\dot{V}O_2max$, $\ell.min^{-1}$*	3.60 ± 0.50	2.31-5.35	2.18 ± 0.32	1.24±3.14	.61
$\dot{V}O_2max$, $m\ell.kgBW^{-1}.min^{-1}$*	51.1 ± 5.1	32.4-63.7	37.5 ± 3.7	24.1-47.1	.73
$\dot{V}O_2max$, $m\ell.kgLBM^{-1}.min^{-1}$*	60.9 ± 5.6	44.4-79.5	52.4 ± 5.4	32.0-70.1	.86
HRmax, $beats.min^{-1}$	190.7 ± 6.8	172-210	189.8 ± 7.4	164-210	-
$\dot{V}_Emax$, $\ell.min^{-1}$(BTPS)*	139.1 ± 21.3	83.9-194.0	88.6 ± 15.7	46.1-131.7	-

* Mean differences significant at 1% confidence level.

TABLE 1. Description of test groups

	Group	Description	n	Age Mean $\pm$ SD
I	Male recruits	New recruits at beginning of initial entry training	210	19.7 ± 2.2
II	Female recruits	New recruits at beginning of initial entry training	212	19.7 ± 1.9
III	Male basic trainees	Completed seven weeks of initial entry training	176	19.1 ± 2.4
IV	Female basic trainees	Completed seven weeks of initial entry training	163	20.4 ± 2.5
V	Advanced male trainees	Completed four months of initial and occupational training	111	20.8 ± 3.4
VI	Stateside (male)	Assigned to units within continental U.S.	199	24.7 ± 5.7
VII	Overseas (male)	Assigned to combat infantry unit overseas	315	23.5 ± 7.9
VIII	Over 40 (male)	Personnel over 40 years of age	503	43.8 ± 3.0

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As might be expected, a high intensity training program (Group VII) obliterated most of the occupational effect although some trend was still evident. This would agree with the idea that there is more training effect from recreational activity than from daily job activities (39). This is based on the concept of an overload stimulus being necessary for an improvement. This can be provided by short bursts of high intensity activity that can occur in recreational or sport activities but seldom occur in occupations.

The final factor investigated in this study was body fat content. It is appropriate to express aerobic capacity in terms of body weight or lean body mass when concerned with whole body mobility activities (5). In this case excess body fat is detrimental to aerobic fitness in two ways. First, in mathematical terms, it increases the denominator, representing tissue weight that cannot utilize oxygen for muscular contraction. Secondly, it may well have a negative motivational effect on the amount of habitual physical activity and aerobic training participation. The end result is a moderate negative relationship between aerobic capacity and percent body fat in these heterogenous samples employed in this study. These data (Figure 4) have been used, in part, to establish body fat standards for Army personnel. While it is recognized these data utilize body fat values from the indirect technique of skinfold measurements, we feel that it is appropriate to use this procedure in this way to describe general population relationships. Furthermore, in a recently completed but as yet unpublished study from this laboratory (Fitzgerald, et al) where percent body fat was measured by densitometry, we observed a correlation coefficient of -0.55 with direct treadmill $\dot{V}O_2$max in a sample of 964 male soldiers, almost identical with the values obtained in this study with skinfold measures.

achieved less of their aerobic potential than men when they enter the military service. At the same time the appetite stimulating effect of the sudden onset of increased physical activity and the change in diet in basic training apparently produces a positive caloric balance in these women.

Maximal oxygen uptake is acutely responsive to training level whether it is training-up or de-training (33). Following initial entry training a soldier undergoes one to two months of advanced occupational training where, on the average, physical training receives less emphasis but is nevertheless a part of the curriculum. Even after this short time the mean $\dot{V}O_2max$ was 2.4% less than at the end of initial entry training. It continued to drop as soldiers moved to normal organizational assignments although the aging effect comes into play (Figure 3). The decline with age can be offset however if these personnel are placed in high intensity training programs as was the case in Group VII. Their mean $\dot{V}O_2max$ was 11% higher than a comparably aged group in a variety of state-side units with a wide range of training intensities. As illustrated in Figure 3, the average age decline of 0.5 $ml \cdot kgBW^{-1} \cdot min^{-1}$ per year agrees well with previous cross-sectional studies (2,10,18,34).

The higher average maximal oxygen uptake observed in officers as compared to non-commissioned officers, as we have reported before (11), is most likely explained by a greater emphasis on appearance and fitness in the officer corps. Peer pressure to maintain a healthier life style is generally more prominent among officers.

Another factor which plays a role in the eventual level of aerobic fitness in large populations is the physical intensity of occupations. This was evident only in the case of the relatively untrained state-side groups.

They are more comparable to the $\dot{V}O_2$max's of 59.4 and 46.0 $ml \cdot kgBW^{-1} \cdot min^{-1}$ for male and female military academy officer cadets that we have reported (8). Some earlier reports (4,6) of low aerobic capacities in United States populations were undoubtedly due to the use of indirect, predictive techniques resulting in values that are not comparable to actual treadmill determinations. This points out the danger of comparing population values using different methods since discrepancies have been documented among treadmill, cycle and stepping (16,26,37,42), between continuous and interrupted protocols (15,25), and between actual oxygen uptake measurement and that predicted from heart rate or exercise intensity (9,32,35). Thus, while the direct treadmill protocol may be time-consuming and elaborate for use in evaluating large samples in "field settings", we believed this to be a minor problem when the trade-off is obtaining the highest, most objective and reproducible assessment of maximal oxygen uptake possible.

The 39 percent difference in aerobic capacity between genders is similar to other reports (1,22,29,31). Nearly two-thirds of this difference can be accounted for by the burden of extra body fat and less lean body mass. If differences in bone mass could be accounted for so that only differences in muscle mass remain, maximal oxygen uptake per kilogram of skeletal muscle in the women would be less than ten percent lower than men.

As previously shown by us in a longitudinal study of basic trainees (31), women show a two to three times greater response in $\dot{V}O_2$ during basic entry training than men. However, they do not lose as much body fat as men do and, therefore, gains on a body weight or lean mass basis are approximately the same as men. This strongly suggests that, on the average, young American women, because of a lower relative level of habitual physical activity, have

TABLE 5. Maximal O_2 uptake and anthropometric variables in male officers and non-commissioned officers 40 years of age and older, Group VIII

	Mean ± SD		Range
	NCOs	Officers	for
	n = 168	n = 335	total sample
Age, yrs	43.4 ± 2.7	43.9 ± 3.2	40-50
Height, cm	177.7 ± 6.6	180.2 ± 6.8	149-201
Body weight, kg	83.7 ±12.7	83.6 ±10.1	56-108
Body fat, % BW	26.2 ± 4.8	24.5 ± 4.3	11-37
$\dot{V}O_2max$, $\ell \cdot min^{-1}$*	3.04± .51	3.38± .50	1.71-4.75
$\dot{V}O_2max$, $ml.kgBW^{-1} \cdot min^{-1}$	36.7 ± 5.5	40.6 ± 6.2	25-61
HRmax, bpm	182 ± 9	180 ± 9	142-204
V_E, $\ell \cdot min^{-1}$ (BTPS)	119 ± 23	126 ± 23	61-219

*Mean differences significant at 5% confidence level.

TABLE 6. Effect of occupational physical intensity level on maximal oxygen uptake, body weight and body fat in groups VI and VII

	Occupational Rating #		
	Heavy	Moderate	Light
<u>Group VI (Variable Training Intensity)</u>			
n	82	20	40
$\dot{V}O_2$max, ml.kgBW^{-1}.min^{-1}**	50.6 $\pm$ 6.4	46.7 $\pm$ 7.7	47.1 $\pm$ 7.5
Body weight kg*	72.2 $\pm$10.0	70.6 $\pm$ 9.4	74.5 $\pm$ 12.0
Body fat, % of BW*	17.2 $\pm$ 5.0	19.6 $\pm$ 6.7	19.99$\pm$ 6.3
<u>Group VII (High Training Intensity)</u>			
n	122	62	81
$\dot{V}O_2$max, ml.kgBW^{-1}.min^{-1}	53.0 $\pm$ 5.0	52.4 $\pm$ 5.9	50.5 $\pm$ 5.7
Body weight, kg	72.2 $\pm$ 10.0	70.6 $\pm$ 9.4	74.5 $\pm$ 12.0
Body fat, % of BW**	18.7 $\pm$ 5.4	18.4 $\pm$ 5.5	20.9 $\pm$ 6.0

** ANOVA F (<.01)   # See text for definition of rating

* ANOVA F (<.05)

TABLE 7. $\dot{V}O_2max$ of young, non-athlete men and women determined by treadmill running.

					$\dot{V}O_2max$	
MALES	n	Age(yr)	Ht(cm)	Wt(kg)	$\ell.min^{-1}$	$m\ell.kg^{-1}.min^{-1}$
Canadian Univ. Students (22)	24	20 ± 1.2	176.5 ± 2.4	76.1 ± 8.8	3.92 ± 0.58	51.7 ± 5.1
Japanese Adolescents (24)	49	17 - 18	167.6 ± 2.2	57.1 ± 4.2	2.79 ± 0.30	49.1 ± 4.0
American PE Students (7)	12	22.3 ± 3.4	178.5 ± 1.5	76.6 ± 2.0	-	51.0 ± 6.8
American College Students (26)	23	20.4 ± 1.8	178.3 ± 6.6	77.3 ± 12.7	3.27 ± 0.51	42.7 ± 4.9
Swedish PE Majors (2)	31	26.9	176.6 ± 1.1	69.9 ± 1.1	4.08 ± 0.07	58.7 ± 0.7
Colombian Laborers (23)	18	25.5 ± 4.5	164.8 ± 5.0	61.4 ± 9.9	2.70 ± 0.48	44.1 ± 3.9
American HS Students (30)	30	17.0 ± 0.48	179.3 ± 6.5	71.2 ± 11.1	3.87 ± 0.54	54.7 ± 6.7
Present Study	210	19.7 ± 2.2	174.7 ± 6.9	70.5 ± 10.7	3.60 ± 0.50	51.1 ± 5.1
FEMALES						
Canadian Univ. Students (22)	24	18.7 ± 0.6	163.3 ± 2.1	59.2 ± 5.9	2.32 ± 0.41	39.1 ± 5.1
Japanese Adolescents (24)	59	17 - 18	155.5 ± 2.5	50.0 ± 4.4	1.93 ± 0.30	39.0 ± 5.5
American PE Students (17)	20	-	-	-	-	41.3
American College Students (19)	27	17 - 22	-	-	2.21 ± 0.21	38.4 ± 4.8
Swedish PE Majors (2)	35	21.9	165.6 ± 0.9	59.8 ± 1.0	2.83 ± 0.05	47.6 ± 0.7
American HS Students (30)	30	17.0 ± 0.53	163.6 ± 8.8	58.4 ± 6.8	2.34 ± 0.26	40.2 ± 4.7
Present Study	212	19.7 ± 1.9	162.0 ± 6.4	58.6 ± 7.0	2.18 ± 0.32	37.4 ± 3.7

FIGURE LEGENDS

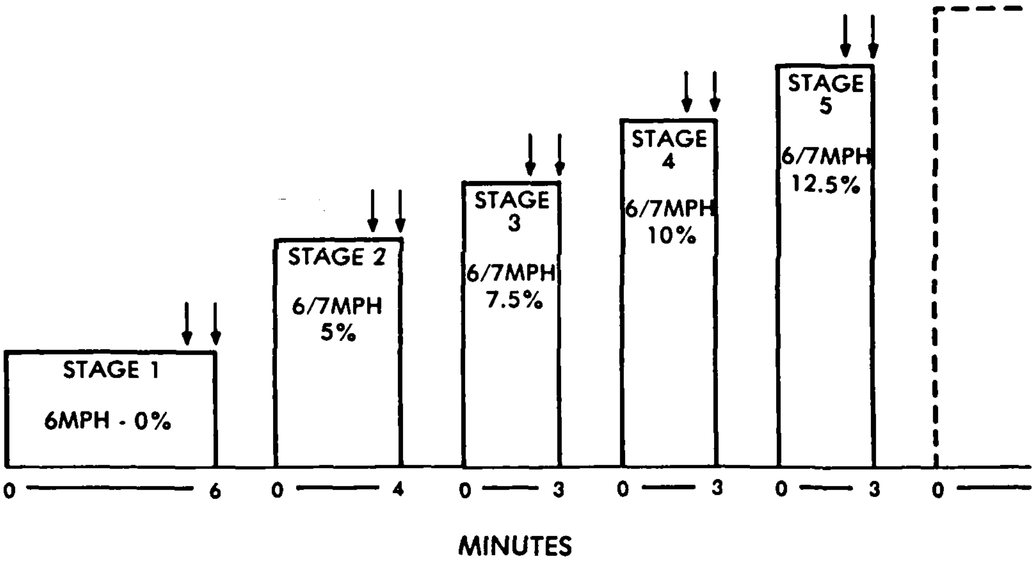
Fig. 1. Protocol employed for direct determination of maximal oxygen uptake by the Douglas bag procedure during treadmill running. Arrows indicate points for gas collections. Speeds are those used for men and are reduced by one mph for women.

Fig. 2 Comparative distribution of maximal oxygen uptake in men-and women recruits at the beginning of basic initial entry training.

Fig. 3 Effects of increasing age on maximal oxygen uptake in three groups of male soldiers.

Fig. 4 Scatter plot relations of maximal oxygen uptake versus percent body fat in two groups of male soldiers.

Figure 1.



STAGE 1
6MPH - 0%
STAGE 2
6/7MPH
5%
STAGE 3
6/7MPH
7.5%
STAGE 4
6/7MPH
10%
STAGE 5
6/7MPH
12.5%
0 — 6
0 — 4
0 — 3
0 — 3
0 — 3
0 —
MINUTES

Figure 2.

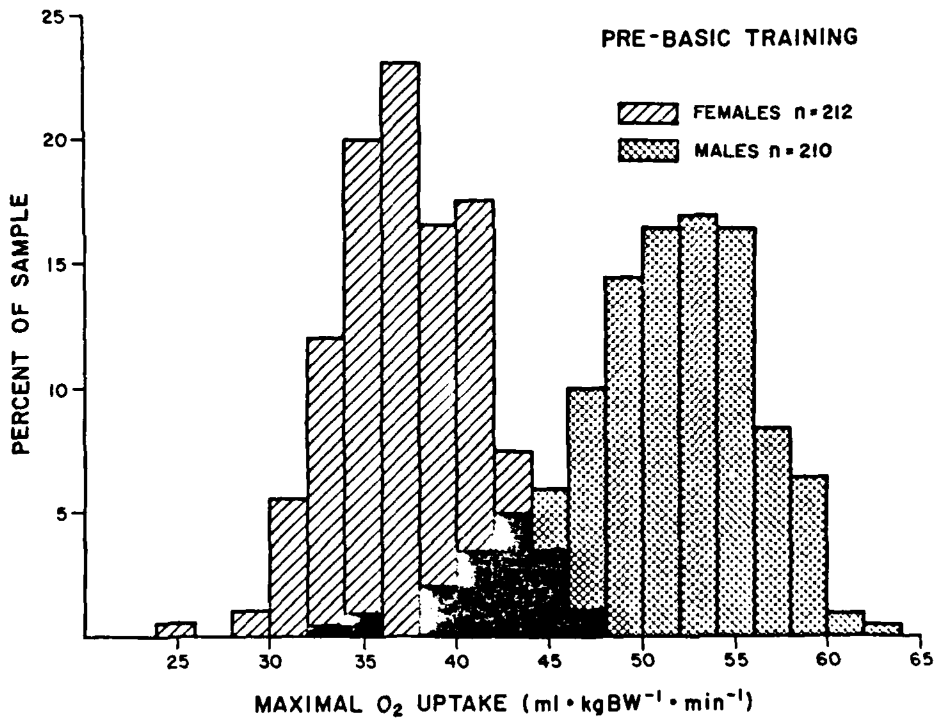
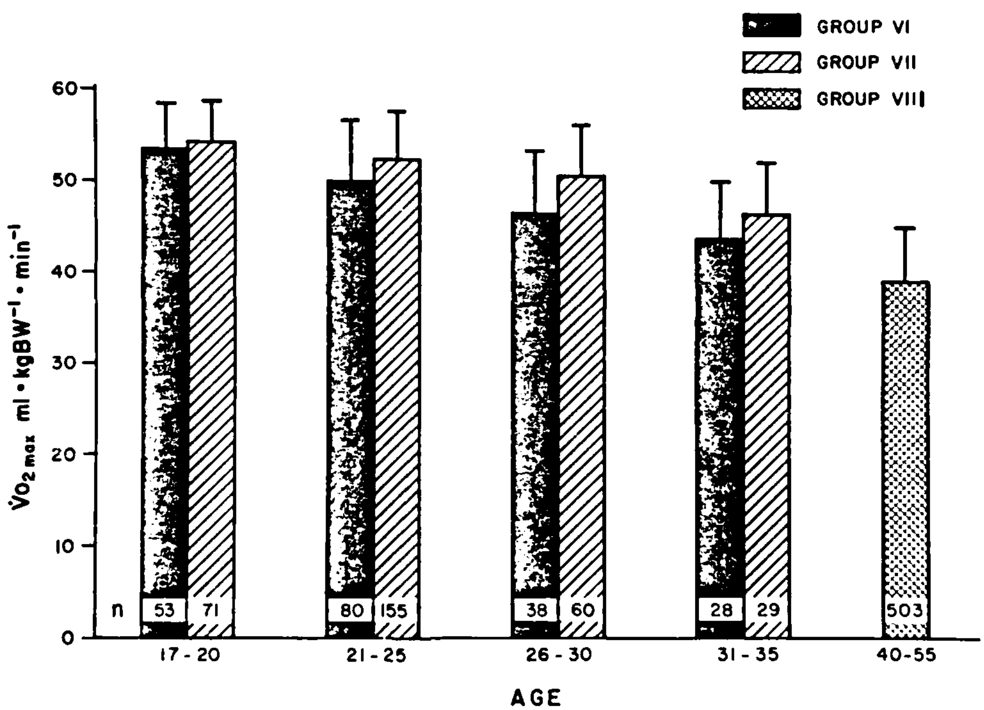
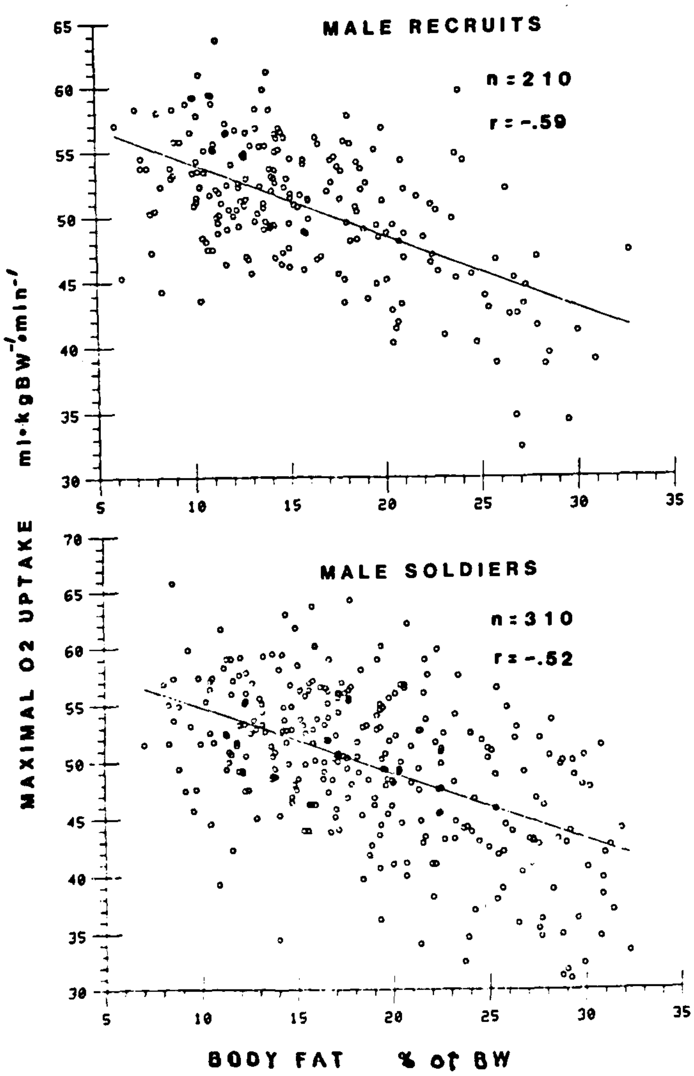

PRE-BASIC TRAINING
FEMALES n=212
MALES n=210
PERCENT OF SAMPLE
25
20
15
10
5
25
30
35
40
45
50
55
60
65
MAXIMAL O_2 UPTAKE (ml • kgBW^{-1} • min^{-1})

Figure 3.



GROUP VI
GROUP VII
GROUP VIII
$\dot{V}O_{2max}$ ml • kgBW^{-1} • min^{-1}
60
50
40
30
20
10
0
n
53
71
80
155
38
60
28
29
503
17 - 20
21 - 25
26 - 30
31 - 35
40-55
AGE

Figure 4.



MALE RECRUITS
n = 210
r = -.59
MALE SOLDIERS
n = 310
r = -.52
MAXIMAL O2 UPTAKE ml•kgBW^{-1}•min^{-1}
BODY FAT % of BW

END

FILMED

8-85

DTIC